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Forest Health Protection Report

Forest Insect and Disease Conditions in Alaska--1999

ALASKA FOREST HEALTH SPECIALISTS

Anchorage

Forest Health Protection
USDA Forest Service
State and Private Forestry
3301 'C' Street, Suite 522
Anchorage, AK 99503-3956
Phone: (907) 271-2575
FAX (907) 271-2897

Jerry Boughton, Program Leader
email: jboughton@fs.fed.us
Edward H. Holsten, Entomologist
email: eholsten@fs.fed.us
Beth Schulz, Ecologist
email: bschulz@fs.fed.us
Lori Trummer, Pathologist
email: ltrummer@fs.fed.us
Kenneth P. Zogas, Biotechnician
email: kzogas@fs.fed.us
Kathleen Matthews, Biotechnician
email: kmatthews03@fs.fed.us

Department of Natural Resources
State of Alaska
Division of Forestry State Office
550 W 7th Avenue, Suite 1450
Anchorage, AK 99501-3566
Phone: (907) 269-8460
FAX (907) 269-8902 / 8931

Roger Burnside, Entomologist
e-mail: rogerb@dnr.state.ak.us

Alaska Cooperative Extension
2221 E. Northern Lights, Suite 118
Anchorage, AK 99508
Phone: (907) 786-6311

Fred Sorenson, IPM Program Coordinator
e-mail: dffes@uaa.alaska.edu

Juneau

Forest Health Protection
USDA Forest Service
State and Private Forestry
2770 Sherwood Lane, Suite 2A
Juneau, AK 99801
Phone: (907) 586-8883
(907) 586-8769
FAX (907) 586-7848

Paul E. Hennon, Pathologist
email: phennon@fs.fed.us
Mark Schultz, Entomologist
email: mschultz01@fs.fed.us
Dustin Wittwer, Biotechnician
email: dwittwer@fs.fed.us

FOREST INSECT AND DISEASE CONDITIONS IN ALASKA -- 1999

General Technical Report R10-TP-82

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Compiled by:
Dustin Wittwer, Biological Technician

Contributors:
Kathleen Matthews, Biological Technician
Ken Zogas, Biological Technician
Lori Trummer, Pathologist
Ed Holsten, Entomologist
Beth Schulz, Ecologist
Paul Hennon, Pathologist
Mark Schultz, Entomologist
Roger Burnside, AK/DOF Entomologist
Dorothy Mortenson, AK/DNR GIS
Jeff Riggs, AK/DNR GIS Analyst
Alaska Cooperative Extension

Forest Health Protection
State and Private Forestry
Alaska Region
USDA Forest Service
3301 "C" Street, Suite 522
Anchorage, Alaska 99503

State of Alaska
Department of Natural Resources
Division of Forestry, State Office
550 W. 7th Avenue, Suite 1450
Anchorage, Alaska 99501-3566

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CONDITIONS IN BRIEF

Aerial detection mapping is conducted annually to document the location and extent of active forest insect and disease damage. These surveys generally cover approximately 1/3 of the forested land in Alaska. Smoke from large wildfires in interior Alaska and inclement weather precluded flights into many areas of concern. Even so, approximately 31 million acres throughout Alaska were surveyed. Insect activity this year impacted the least number of recorded acres in over 8 years. The most important diseases and declines in Alaska are characterized as chronic conditions and remain relatively unchanged.

INSECTS:

Total area of active **Spruce Beetle** infestation fell again in 1999 to only 253,265 acres, continuing a decline in mapped acreage, which began in 1997. The 1999 acres represent a 19% decline from 1998 levels and a 77% decline from 1996 levels when beetle-impacted areas peaked at 1.1 million acres. Population levels in areas which have recently been heavily impacted, such as Iliamna Lake, the Copper River Valley, the west side of Cook Inlet, the Anchorage Bowl, the northern Kenai Peninsula and the eastern portion of Kachemak Bay have declined dramatically due to lack of host material. Some active areas persist, where suitable host material remains or where new areas of disturbance present the spruce beetle with fresh opportunities for population increases. Heavy activity continues near Lake Clark along the Tlikakila River and in the Hanagita River Valley in the Wrangell-St. Elias National Park and Preserve.

Total spruce beetle activity in southeast Alaska decreased from a high of 35,700 acres in 1996 to 6,556 acres in 1999, mostly in the Chilkat and Chilkoot drainages north of Haines. There were 1,424 acres of activity in Glacier Bay National Park east of Gustavus. The infestation on the Taku River near the Canadian border has almost completely collapsed.

Spruce needle aphid occurred on 4,253 acres in Southeast Alaska from the southern end of Prince of Wales Island to Tenekee Inlet, Chichagof Is. in 1999. This was a 90% reduction from 1998 acres. Sitka spruce were affected along the beach fringe and not up the slope as in 1998.

Spruce budworm activity decreased in 1999; only 708 acres of white spruce were defoliated compared to 87,800 defoliated acres last year. After more than five consecutive years, the budworm outbreak along the Yukon River appears to have run its course.

Willow leaf blotchminer defoliation rose for the second consecutive year; more than 180,396 acres of defoliated willow were aerially detected in 1999 vs. 120,000 acres in 1998. Similar to last year, most of the willow defoliation is located in the upper Yukon and Porcupine River valleys.

Acres of aspen affected by **Large Aspen Tortrix** defoliation declined by 41% in 1999 to 13,336 acres, consistent with the cyclic nature of this insect. Tortrix activity was confined almost exclusively to interior Alaska with the exception of a small, but persistent population located near Skilak Lake on the Kenai Peninsula.

Larch sawfly continues to be quite active throughout the range of larch in interior Alaska. Defoliation, however, was significantly reduced over 1998 levels. Approximately 190,000 acres of defoliated larch were detected this year vs. more than 400,000 acres of defoliated larch in 1998. In many of the defoliated areas, patches of larch mortality are beginning to appear; either due to the direct effects of the sawfly or by the larch beetle attacking stressed, defoliated trees. The major area of sawfly activity continues to be from the Alaska Range west to the Kuskokwim River. Larch sawfly was detected for the first time south of the Alaska Range in the Mat-Su Valley and Anchorage Bowl defoliating ornamental larch. This was no doubt an accidental introduction.

In southeast Alaska, **Hemlock sawfly** defoliation levels decreased over the last three years from 8,250 acres in 1996 to 89 acres in 1999.

DISEASES:

The most important diseases and declines of Alaskan forests in 1999 were wood decay of live trees, root disease of white spruce, hemlock dwarf mistletoe, and yellow-cedar decline. Except for yellow-cedar decline, trees affected by these diseases are difficult to detect by aerial surveys. Nonetheless, all are chronic factors that significantly influence the commercial value of the timber resource and alter key ecological processes including forest structure, composition, and succession. Wildlife habitat is enhanced through the development of hollow tree cavities by heart rot fungi, and witches' brooms by hemlock dwarf mistletoe and broom rust fungi.

In southeast Alaska, approximately one-third of the gross volume of forests is defective due to **stem** and **butt rot fungi**. **Hemlock dwarf mistletoe** continues to cause growth loss, top-kill, and mortality in old-growth forests; its impact in managed stands depends on the abundance of large infected trees remaining on site after harvesting. Approximately 493,000 acres of **yellow-cedar decline** have been mapped across an extensive portion of southeast Alaska. Snags of yellow-cedar accumulate on affected sites and forest composition is substantially altered as yellow-cedar trees die, giving way to other tree species. Salvage opportunities for this valuable resource are now being recognized.

In south-central and interior Alaska, **tomentosus root rot** continues to cause growth loss and mortality of white spruce in all age classes. Stem, butt, and root rot fungi cause considerable defect in white spruce, paper birch and aspen stands. Saprophytic decay of spruce bark beetle-killed trees, primarily caused by the **red belt fungus**, continues to rapidly develop on and degrade dead spruce trees.

Spruce needle rust occurred at high levels in several areas of southeast Alaska and endemic levels across south-central Alaska. **Willow rust** occurred at moderate levels in interior Alaska in 1999. Acres reported by aerial survey observers for the rust fungi should be considered conservative because the diagnostic foliar discoloration appears most pronounced on trees several weeks after survey flights. Cone and other foliar diseases of conifers were generally at low levels throughout Alaska in 1999. Canker fungi were at endemic levels, causing substantial, but unmeasured, damage to hardwood species in south-central and interior Alaska.

Other:

In localized areas of southeast Alaska, feeding by porcupines and brown bears continues to cause tree damage to several conifer species.

Table 1. 1999 forest insect and disease activity as detected during aerial surveys in Alaska by land ownership and agent[1]. All values are in acres.

Damage Agent	State & Private	National Forest	Other Federal	Native Corp.	Total 1999	*Difference From 1998*
Willow Defoliation	19,360	0	72,595	88,441	180,396	+57,326
Larch Beetle	20,256	0	3,265	6,795	30,316	+30,316
Yellow-cedar Decline[2]	23,563	449,395	323	20,462	493,743	+14,661
Birch Defoliation	324	0	2,421	8	2,753	+2,720
Water Damage	617	119	1,518	318	2,572	+1,742
Porcupine Damage	0	327	0	18	345	+265
Hemlock Canker	0	0	0	257	257	+257
Blowdown/Windthrow	18	264	114	0	396	+246
Willow Rust	309	0	17	207	533	-7
Landslide Damage	3	61	11	0	75	-145
Cottonwood Defoliation	1,745	0	1,744	2,101	5,590	-1,020
Hemlock Sawfly	18	71	0	0	89	-3,841
Engraver Beetle	226	0	347	697	1,270	-8,030
Large Aspen Tortrix	4,973	0	3,975	4,388	13,336	-8,494
Engravers/Spruce Beetle	833	0	865	810	2,508	-10,662
Spruce Needle Aphid	1,212	2,653	321	67	4,253	-42,087
Spruce Beetle	110,845	6,415	113,614	22,391	253,265	-63,535
Spruce Budworm	570	0	0	139	708	-87,092
Larch Sawfly	12,626	0	134,234	12,400	159,260	-302,520
Total Acres	**197,498**	**459,305**	**335,364**	**159,499**	**1,151,665**	**-419,900**

[1] Table entries do not include many of the most destructive diseases (e.g., wood decays and dwarf mistletoe) because these losses are not detectable in aerial surveys.

[2] Value of yellow-cedar decline is not restricted to the acreage with a high concentration of dying trees for this year; it represents stands that generally have long-dead trees, recently-dead trees, dying trees, and some healthy trees. See discussion of yellow-cedar decline for a detailed listing of affected acreage.

Table 2. Acreage having active insect damage, by year since 1994, and the cumulative area (in thousands of acres) affected for the last 6 years.

Damage Agent	1994 Total	1995 Total	1996 Total	1997 Total	1998 Total	1999 Total	Cumulative Totals[1]
Spruce beetle	610.2	893.9	1,133.0	563.7	316.8	253.3	**2195.7**
Larch sawfly	0.3	116.9	606.9	267.6	461.8	159.3	**1485.7**
Spruce budworm	232.1	279.3	235.9	38.4	87.8	0.7	**577.6**
Willow defoliation	12.5	5.6	50.1	3.5	123.1	180.4	**350.5**
Black-headed budworm	188.1	13.0	1.2	30.8	--	--	**233.4**
Large aspen tortrix	9.2	32.4	6.4	5.1	21.8	13.3	**84.8**
Engravers/spruce beetle[2]	22.5	5.6	13.9	8.8	13.2	3.9	**72.9**
Spruce needle aphid	1.5	0.1	0.5	24.8	46.4	4.3	**52.1**
Hemlock sawfly	3.0	1.1	8.3	6.6	3.9	--	**22.8**
Cottonwood defoliation	3.8	3.5	5.4	3.0	6.6	5.6	**20.7**
Birch defoliation	--	0.9	3.2	5.4	0.1	2.8	**12.2**
Total thousands acres	**1,083.2**	**1,352.3**	**2,064.8**	**957.7**	**1,081.5**	**623.6**	**5108.4**

1 The same stand can have active infestation for several years. The cumulative total is a union of all areas for 1993 through 1998.

2 These tallies represent polygons coded to ipb (*Ips* and spruce beetle combination) and polygons coded only to *Ips*.

THE ROLE OF DISTURBANCE IN ECOSYSTEM MANAGEMENT

To the casual observer, forests may appear to be unchanging. In fact, most forests are in some stage of re-establishment after one or more disturbances. In Alaska, geological processes, climatic forces, insects, plant diseases, and the activities of animals and humans have shaped forests. To practice ecosystem management, we must understand how these cycles of disturbances have shaped and continue to influence various forest ecosystems.

Disturbances result in changes to ecosystem function. In forests, this often means the death or removal of trees, but other forms of disturbance can be slow, gradual changes in environmental conditions. Disturbances caused by physical forces such as volcanoes, earthquakes, storms, droughts, and fire can affect the entire plant community, although some species may be more resistant to damage than others. Insects, plant diseases, animal and human activities are usually more selective, directly affecting one or several species.

Figure 1. Wind disturbance is a common precursor to other forms of disturbance such as bark beetles, fire and landslides.

Cycles of disturbance and recovery repeat over time and across landscapes. From evidence of past disturbances on a landscape, we can predict what type of disturbance is likely to occur in the future. Landscapes supporting large areas of single age stands indicate rare, but intense large-scale disturbances. Landscapes with a variety of age classes and species suggest more frequent smaller scale events. Usually, several types of disturbances at various scales of space, time, and intensity have influenced forest structure and composition on a given site. The role of disturbance in ecological processes is well illustrated in Alaska's two distinct forest ecosystem types and transition zones.

The temperate rain forests of southeast Alaska are dominated by western hemlock and Sitka spruce. Alaskan yellow-cedar, western red cedar, shore pine and mountain hemlock are also important components. Trees on productive sites can attain great size due to abundant rainfall and moderate temperatures. Wind is the major disturbance agent in southeast. Degree of impact and scale depends on stand composition, structure, age and vigor and as well as wind speed, direction, duration and topographic effects on wind flow. The forest type most susceptible to wind throw is mature spruce-hemlock on productive, wind-exposed sites. The large, top-heavy canopies act as sails and uprooting is common, resulting in soil churning, which expedites nutrient cycling and increases soil permeability. Even-aged forests develop following large-scale catastrophic wind events. Old-growth forest structure develops in landscapes protected from prevailing winds. In these areas, small gap-forming events dominate. Trees are long-lived, but become heavily infected with heart-rot fungi, hemlock dwarf mistletoe, and root rot fungi as they age. Weakened trees commonly break under the stress of gravity and snow loading. Canopy gaps generated this way do not often result in exposed mineral soil.

The boreal forests of interior Alaska are comprised of white spruce, black spruce, birch, aspen and poplar. The climate is characterized by long, cold winters, short, hot summers, and low precipitation. Cold soils and permafrost limit nutrient cycling and root growth. Topographic features strongly influence microsite conditions; north-facing slopes have wet, cold soils, whereas south-facing slopes are warm and well drained during the growing season. Soils are usually free from permafrost along river drainages, where flooding is common. Areas more distant from rivers are usually underlain by permafrost and are poorly drained. Fire is the major large-scale disturbance agent; lightening strikes are very common. All tree species are susceptible to damage by fire, and all are adapted, to various degrees, to regeneration following fire. Fire impacts go beyond removal of vegetation; depending on the intensity and duration of a fire, soil may be warmed, upper layers of permafrost may thaw, and nutrient cycling may accelerate. Patterns of forest type development across the landscape are defined by the basic silvics of the species involved. Hardwoods are seral pioneers, re-sprouting from roots or stumps. White spruce stands are usually found on better-drained soils, along flood plains, river terraces, and on slopes with southern exposure. Black spruce and tamarack occur in areas of poor drainage, on north-facing slopes, or on upland slopes more distant from rivers where permafrost is common.

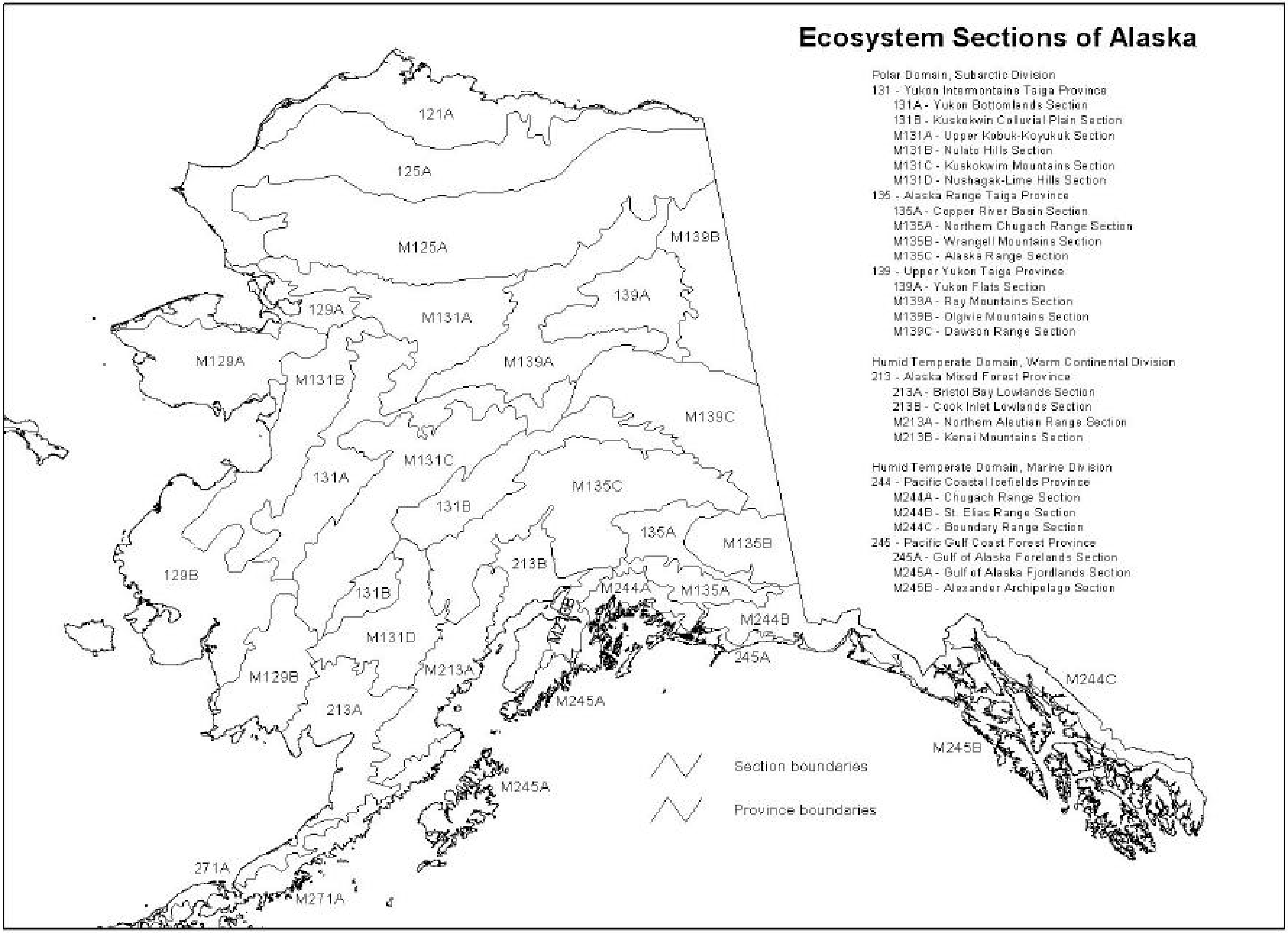
South-central Alaska is a transition zone between the coastal marine climate of southeast and the continental climate of the interior. These forest communities are more similar to those in the interior, except where Sitka spruce and white spruce ranges overlap and the Lutz spruce hybrid is common. Fire has been a factor in the forest landscape patterns we see today. These fires, however, were mostly the result of human activity; lightning strikes are uncommon in the Cook Inlet area. Major disturbances affecting these forests in the past century have been human activity and spruce beetle caused mortality. Earthquakes, volcanic eruptions, and flooding following storm events have also left significant signatures on the landscape.

Disturbances play an important role in shaping forest composition, structure, and development. With knowledge of disturbance regimes, managers can understand key processes driving forest dynamics and gain insight into the resiliency (the ability to recover) and resistance (the ability to withstand change) of forests to future disturbance. As we improve our understanding of the complexities of these relationships, we are better able to anticipate and respond to natural disturbances and mimic the desirable effects with management activities. Ecological classification is one tool available to help us understand disturbance patterns.

Several useful systems of classification have been developed for Alaska's ecosystems and vegetation. On-going efforts to refine and standardize these classifications across all ownership's will promote effective ecosystem management. ECOMAP (1993) is one system of ecological classification that the Forest Service has adopted and continues to develop. Within this hierarchical system, ecosystems are delineated at multiple scales using different sets of environmental factors. The levels established at this time include Domains, Divisions, Provinces and Sections. Domains represent sub-continental climatic zones. Divisions and Provinces represent climatic sub-zones as reflected by dominant life forms (meadows vs. forests) and broad vegetation types, respectively. Geomorphic and topographic features distinguish sections. The Section level is the first level of the hierarchy where analysis of insect and disease activity becomes applicable.

Throughout this report, we make reference to the Ecosystem Sections of Alaska (see the following page). This map was developed for the Alaska Region (Nowacki and Brock 1995). Section descriptions are included in Appendix D with a list of typical damaging agents. Only Sections where forest cover occurs are described. As the ecological hierarchy classification and mapping are developed to finer scales, they become more valuable as management tools to predict the impacts of various disturbances on forest resources.

Figure 2. In the temperate rainforests of southeast Alaska frequent small scale canopy gaps are a primary form of disturbance. Heart rot fungi weakened the structural support of trees, which can lead to bole breakage.


Ecosystem Sections of Alaska
Polar Domain, Subarctic Division
131 - Yukon Intermontaine Taiga Province
131A - Yukon Bottomlands Section
131B - Kuskokwin Colluvial Plain Section
M131A - Upper Kobuk-Koyukuk Section
M131B - Nulato Hills Section
M131C - Kuskokwim Mountains Section
M131D - Nushagak-Lime Hills Section
135 - Alaska Range Taiga Province
135A - Copper River Basin Section
M135A - Northern Chugach Range Section
M135B - Wrangell Mountains Section
M135C - Alaska Range Section
139 - Upper Yukon Taiga Province
139A - Yukon Flats Section
M139A - Ray Mountains Section
M139B - Olgivie Mountains Section
M139C - Dawson Range Section
Humid Temperate Domain, Warm Continental Division
213 - Alaska Mixed Forest Province
213A - Bristol Bay Lowlands Section
213B - Cook Inlet Lowlands Section
M213A - Northern Aleutian Range Section
M213B - Kenai Mountains Section
Humid Temperate Domain, Marine Division
244 - Pacific Coastal Icefields Province
M244A - Chugach Range Section
M244B - St. Elias Range Section
M244C - Boundary Range Section
245 - Pacific Gulf Coast Forest Province
245A - Gulf of Alaska Forelands Section
M245A - Gulf of Alaska Fjordlands Section
M245B - Alexander Archipelago Section
121A
125A
M125A
M139B
139A
129A
M131A
M129A
M131B
M139A
M139C
M131C
131A
M135C
131B
135A
M135B
213B
129B
131B
M244A
M135A
M244B
M131D
245A
M129B
M213A
M244C
213A
M245A
M245B
Section boundaries
Province boundaries
M245A
271A
M271A

STATUS OF INSECTS

INSECTS AS AGENTS OF DISTURBANCE

Insects are active and significant components of Alaska's ecosystems. Arctic/boreal insects are characterized by having few species and large population numbers. Boreal insects are opportunistic in their behavior. They respond quickly to changes in climate and the availability of food and breeding material. The spruce beetle, for example, responds quickly to large-scale blowdown, fire-scorched trees, and spruce injured by flooding. Large numbers of beetles can be produced in such breeding material, leading to potential outbreaks.

Spruce beetles are one of the most important disturbance agents in mature white spruce stands in south-central and interior Alaska. A variety of changes occur to forest resources when many trees are killed. In the long run these changes are biological or ecological in nature. There are also socio-economic consequences in the short-term that can be viewed as either positive or negative, depending on the forest resource in question. Some of the impacts associated with spruce beetle infestations include, but are not limited to:

1. Loss of merchantable value of killed trees: The value of spruce as saw timber is reduced within three years of attack in south-central Alaska due to weather checking and sap-rots. The value of a beetle killed trees as house logs, chips, or firewood continues for many years if the beetle-killed tree remains standing.

2. Long term stand conversion: The best regeneration of white and Lutz spruce and birch occurs on a seedbed of bare mineral soil with some organic material. Site disturbances such as fire, windthrow, flooding, or ground scarification provide excellent sites for germination and establishment of seedlings if there is an adequate seed source. However, on some sites in south-central Alaska, grass and other competing vegetation quickly invade the sites where spruce beetles have "opened up" the canopy. This delays re-establishment of tree species. Regeneration requirements for Sitka spruce are less exacting; regeneration is thus, less problematic.

3. Impacts to wildlife habitat: Wildlife populations, which depend on live, mature spruce stands for habitat requirements may decline. We expect to see decreases in red squirrels, spruce grouse, Townsend Warblers, and possibly Marbled Murrelet populations. On the other hand, wildlife species (moose, small mammals and their predators, etc.) that benefit from early successional vegetation such as willow and aspen may increase as stand composition changes.

4. Impacts to scenic quality: Scenic beauty is an important forest resource. It has been demonstrated that there is a significant decline in public perception of scenic quality where spruce beetle impacted stands adjoin corridors such as National Scenic Byways. Maintaining or enhancing scenic quality necessitates minimizing impacts from spruce beetle infestations. Surveys have also shown that the public is evenly divided as to whether spruce beetle outbreaks damage scenic quality in backcountry areas.

5. Fire hazard: There is concern that fire hazard in spruce beetle impacted stands will increase over time. After a spruce beetle outbreak, grass or other fine vegetation increases; fire spreads rapidly through these vegetation types. As the dead trees break or blow down (5-10 years after an outbreak), large woody debris begins to accumulate on the forest floor. This material (boles) is the largest component of the fuels complex. Heavy fuels do not readily ignite, but once ignited they burn at higher temperatures for a longer period. The combination of fine, flashy fuels and abundant large woody debris results in a dangerous fire behavior situation. Rate of fire spread may increase as well as burn intensity. Observations from recent fires on the Kenai Peninsula have shown an increase in crown fires. This fire behavior is caused by fire traveling up the dead spruce trees and spotting into the crowns of adjacent beetle killed trees.

6. Impact to fisheries: If salmon spawning streams are bordered by large diameter spruce and these trees are subsequently killed by spruce beetles, there is a concern as to the future availability of large woody debris in the streams. Large woody debris in spawning streams is a necessary component for spawning habitat integrity.

7. Impact to watersheds: Intense bark beetle outbreaks can kill large amounts of forest vegetation. The "removal" of significant portions of the forest will impact to some degree the dynamics of stream flow, timing of peak flow, etc. There have been no hydrologic studies in Alaska quantifying or qualifying impacts associated with spruce beetle outbreaks. Impact studies, however, have been done elsewhere. In Idaho watersheds impacted by the Mountain Pine Beetle, there was a 15% increase in annual water yield, a 2-3 week advance in snowmelt, and a 10-15% increase in low flows.

There are a variety of techniques that can be used to prevent, mitigate, or reduce impacts associated with spruce beetle infestations. However, before pest management options can be developed, the resource objective(s) for a particular stand, watershed, landscape, etc. must be determined. The forest manager must evaluate the resource values and economics of management actions for each stand in light of management objectives. The beetle population level must also be considered because population levels will determine the priority of management actions and the type of strategy to be invoked. The key to forest ecosystem management is to manage vegetation patterns in order to maintain species diversity, both plant and animal, while providing for a multitude of resources such as recreation, fisheries, wildlife, and the production of wood fiber. Properly applied silvicultural practices as well as fire management in south-central and interior Alaska, can maintain the forest diversity needed to provide the range of products and amenities available in the natural forest for now and in the future.

BARK BEETLES

Spruce Beetle

Dendroctonus rufipennis Kirby

Since 1996, when total area impacted by spruce beetles peaked at 1.1 million acres, populations have fallen by 77%. This is the lowest figure in the past 10 years. Only 253,265 acres of on-going and new spruce beetle infestations were noted in 1999.

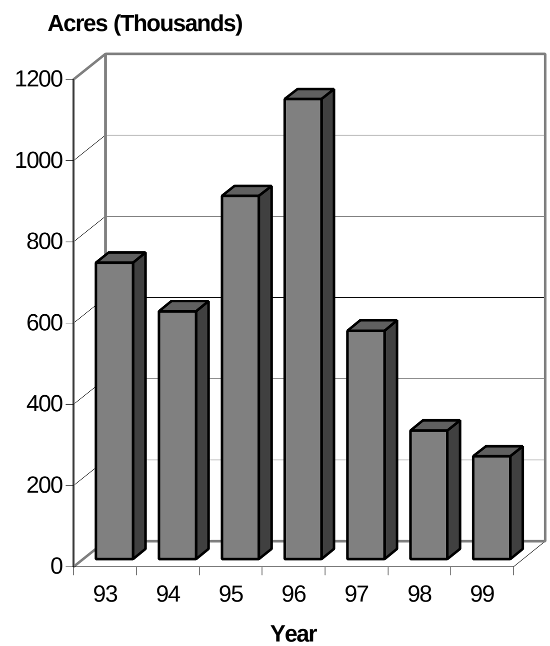


Figure 3. Acres of ongoing and new spruce beetle infestations in Alaska, 1993-1999.

Despite this overall decline, there remain spots of heavy activity, increasing populations and movement into areas as yet undisturbed by the beetle. Continued, smaller-scale activity also persists in areas where suitable host material remains or where new areas of disturbance present beetles with the opportunity for population increases.

Many previous areas of active beetle infestation have been reduced over time to levels considered endemic, as essentially all available host material have been killed. For example, in the majority of the Copper River Valley (135A), Iliamna Lake (M213A), the northern portion of the Kenai Peninsula (M213B), the eastern end of Kachemak Bay and the Anchorage Hillside (213B), the severity of the infestation has declined significantly. Overall, active acreage on the

Chugach National Forest has declined by over 50% for the second year and this trend is expected to continue.

Activity continues on the Chugach National Forest, however, in the vicinity of Trail Lakes, Granite Creek and along the Six-Mile River, while just off the Forest, light to moderate infestations were noted in the valleys of Bird and Indian Creek and in the Ship Creek Valley (all in M213B).

The beetle activity on the northern portion of the Kenai Peninsula remains static, but activity is still observed on the lower Peninsula particularly in a band 1-3 miles wide along the eastern shore of Cook Inlet from Happy Valley to Homer (213B). On the south side of Kachemak Bay, beetles remain quite active between Tutka Bay and Seldovia (M245A). The activity is most intense in the Tutka Bay area, gradually lessening in intensity while moving west toward Seldovia. Activity along the eastern portion of the Bay including Bradley Lake and the Fox River Valley has returned to endemic levels (M244A).

The Susitna valley (213B) remains fairly static in numbers of affected acres. Though the total area affected has risen slightly since last year, the infestation falls within what would be considered endemic levels. This is characteristic of a beetle population progressing in mixed forest-types heavily populated by birch and aspen with a mosaic of age classes. Much of the activity is located along the Susitna River where river bank erosion provides the beetle with fresh opportunities for locating brood material in the form of fallen, large-diameter, green trees.

In the Copper River Valley (135A) spruce beetle activity is now occurring in a narrow band along the Copper River running from Copper Center to Chitina. Much of this activity falls in the "light to moderate" category.

Further south, along the Bremner and Tana Rivers (M135A), intense beetle activity continues with many of the stands totally infested. Activity is quite heavy; nearly 100% of the spruce in these areas are infested. Continuation of this infestation, especially at these severe levels, is in doubt due to depletion of the spruce resource.

Much of the activity in the immediate area of McCarthy has fallen to endemic levels. Some small-scale activity persists, but is characterized as "light" activity. Some light activity persists as well along the Chitina River between the Tebay River and the confluence of the Tana and Nizina Rivers. This activity has been in progress for several years and will probably persist at these levels for several years as many susceptible stands of spruce remain. The area of most intense beetle activity was observed along the Hanagita River (M135A), where more than 22,000 acres of intense activity were mapped. It appears this infestation may have been in progress for at least one to two years, but has not been flown until 1999. This drainage, as well as nearby, associated valleys, will be evaluated again during aerial surveys in the summer of 2000.

In the Lake Clark area, beetle activity remains quite high along the Tlikakila River (M213A) where nearly 13,000 acres of active infestations were observed. This outbreak has persisted for several years and most of these susceptible stands have already been heavily impacted. The outbreak should ending, unless it spills over into Lake Clark National Park. Thus far, movement westward into the Park has been unsuccessful. Although vast areas of contiguous spruce forest exist just west of the intense activity in the Lake Clark Pass area, for reasons little understood, the beetle has been unable to exploit this large, untouched resource.

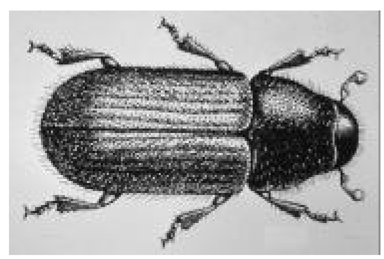


Figure 4. ***Dendroctonus rufipennis****.*

The final area of active infestations is located on the west shore of Cook Inlet (213B), specifically between the McArthur and Beluga Rivers. This includes the area of the West Forelands where activity persists, but it has lessened in severity due to the dwindling host type. The infestations located in the vicinity of Big River Lakes and the entrance to Lake Clark Pass has essentially run its course, killing a majority of the host type. Scattered areas of activity are still present throughout the entire area, but add little to the overall impact. One new area of activity was mapped near Little Mt. Susitna and warrants watching during the next few flight seasons.

Scattered activity persists along the Kuskokwim River primarily downstream from McGrath and along the

Big River (M131C). This activity has persisted for a number of years, but has not expanded to levels that would generate concern. Small-scale logging operations downriver from McGrath continue to operate in the midst of these areas impacted by the beetle. 1,816 acres of beetle activity were noted this year near Sleetmute possibly as a result of the stress placed on these stands by flooding in the past few years. Recent wildfires in this area may have mitigated some of this problem.

Other new areas of beetle activity are Nabesna (M135B), Lime Hills (M131D), Russian Mission (129B) and Candle (M129A). These areas will continue to be monitored as time and resources allow. Rapid development of these small outbreaks is not occurring do to forest type and environmental conditions.

Figure 5. Bark beetle gallery patterns

Spruce beetle activity in southeast Alaska's Sitka spruce forests declined about 82% to 6,556 acres in 1999 from 1996 infested acres. Sixty-six percent of these acres were on the Tongass National Forest. Fifty-nine percent of these acres were in the driest precipitation zone (zone 1, 0-60 inches per year) of the Chilkat and Chilkoot River basins (***Figure 6***). Twenty-four percent of these acres were in the next driest zone (zone 2, 61-92 inches per year) (Lynn Canal, Glacier Bay National Park, upper Taku River and lower Stikine River, most of Admiralty Island, east side of Zarembo Island, east side of Mitkof Island, west and south side of Etolin Island). Fifteen percent of these acres were in the next to the wettest zone (zone 3, 93-150 inches per year) (Yakutat Forelands and south along the coast to Dundas Bay, most of Chichagof Island, the south end of Kuiu Island, south and east half of Kupreanof Island, most of Prince of Wales island, Behm Canal, and south of Smeaton Bay to Portland Canal). Only two percent of these acres were in the wettest zone (zone 4, 151-300 inches per year) (upland areas, east side of Baranof Island, south end of Kuiu Island, east side of Dall Island, and the south end of Prince of Wales Island).

Engravers

Ips perturbatus Eichh.

In one year (1999), engraver activity declined by 59% from 9,290 acres to 3,778. Oftentimes, it is difficult to delineate the causal agent of spruce mortality within a beetle outbreak from the air. In some situations, *Ips* beetle may be active alongside spruce beetle. Therefore, what may be identified as spruce beetle mortality from aerial survey data may be *Ips* activity, or even a combination of the two beetles working in consort. Frequently, *Ips* populations will build quickly in the tops of spruce trees infested by spruce beetle. In areas of large-scale spruce beetle activity, great quantities of brood host material are provided for *Ips* in the form of the tops of these stressed trees. On the Kenai Peninsula, it has been noted particularly in cut-over areas, that *Ips* beetles tend to build in numbers when shaded slash greater than 4 inches in diameter has been left on the ground following logging activity. If enough suitable brood material remains, *Ips* numbers can increase to levels large enough to infest standing, healthy trees. This has been the case with *Ips perturbatus*, a particularly aggressive species of *Ips*. The subsequent population build-up of this species can have a significant negative impact on the survival of residual trees within the stand.

Ips beetle activity in interior Alaska is most often associated with disturbances such as riverbank erosion, top breakage, logging, or wind. Along many of the interior rivers, riverbank erosion is the precipitating event for small-scale outbreaks and much of the endemic activity. Such has been the case for much of the activity in the upper Yukon River (131A) valley and its associated drainages for the past several years. During 1999 aerial surveys, all recent, small-scale outbreaks, such as those on the Christian and Sheenjek Rivers (M139A), have declined to endemic levels.